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US 5863810 A
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US 20030075355 A1

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(71) Applicant(s):
Agilent Technologies, Inc.
(Incorporated in USA - Delaware)
PO Box 10395, 395 Page Mill Road,
Palo Alto, CA 94306-0870,
United States of America

(72) Inventor(s):
Robert E Wilson

(74) Agent and/or Address for Service:
Williams Powell
Morley House, 26-30 Holborn Viaduct,
LONDON, EC1A 2BP, United Kingdom

(54) Abstract Title: **Optoelectronic surface mount package**

(57) The package has an optoelectronic chip 22 on a circuit board substrate 24 and an optical element (eg a window, filter or lens) mounted on the optoelectronic chip. An encapsulating layer 28 covers the exposed surfaces of the chip but only partially covers the optical element. A dam may be provided on the substrate for depositing and shaping the encapsulation layer and BGA contacts provide electrical connections to the package.

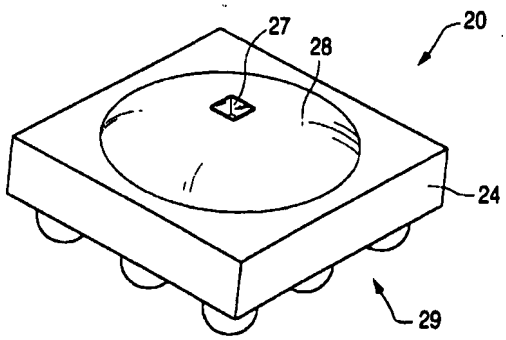

FIG. 4

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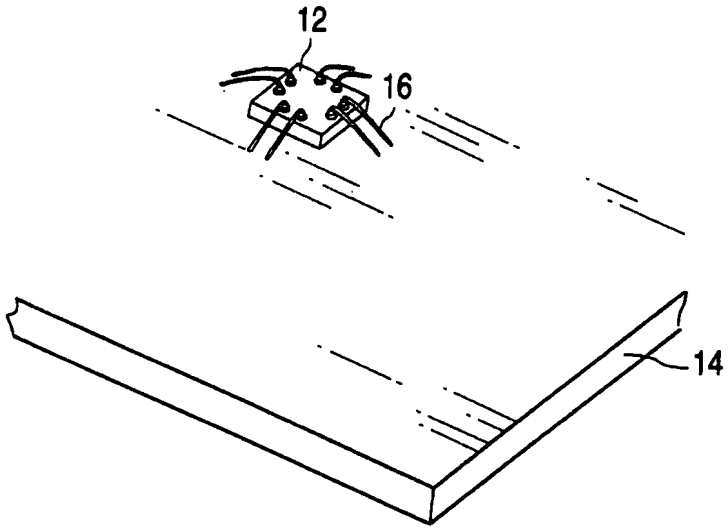

FIG. 1
(PRIOR ART)

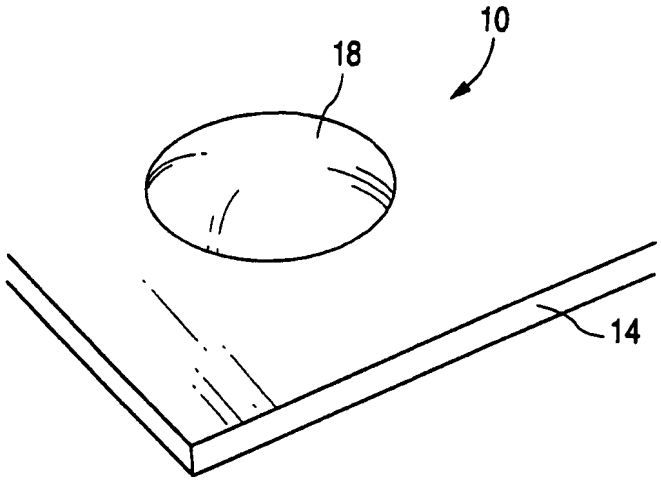

FIG. 2
(PRIOR ART)

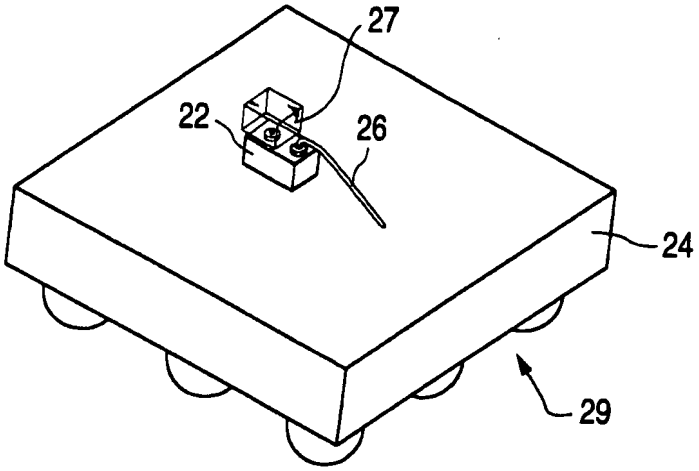

FIG. 3

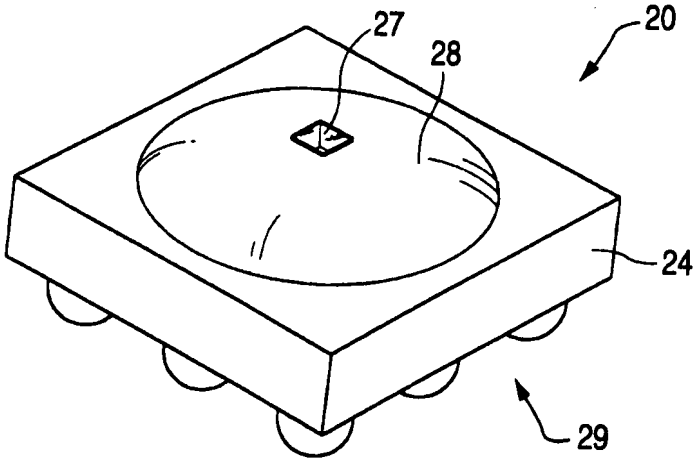

FIG. 4

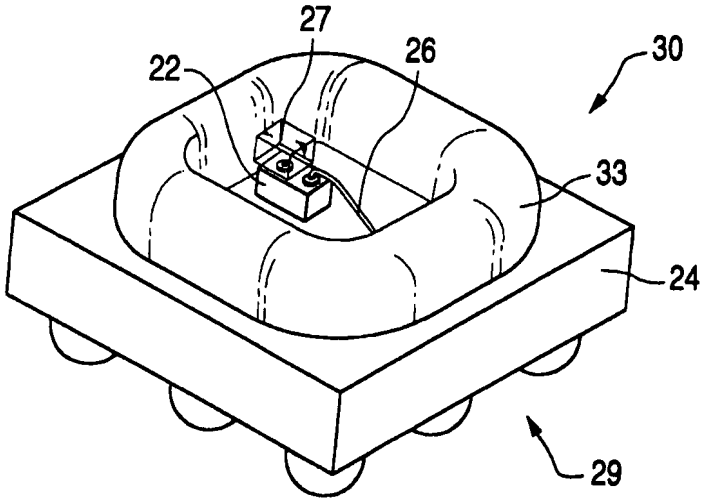

FIG. 5

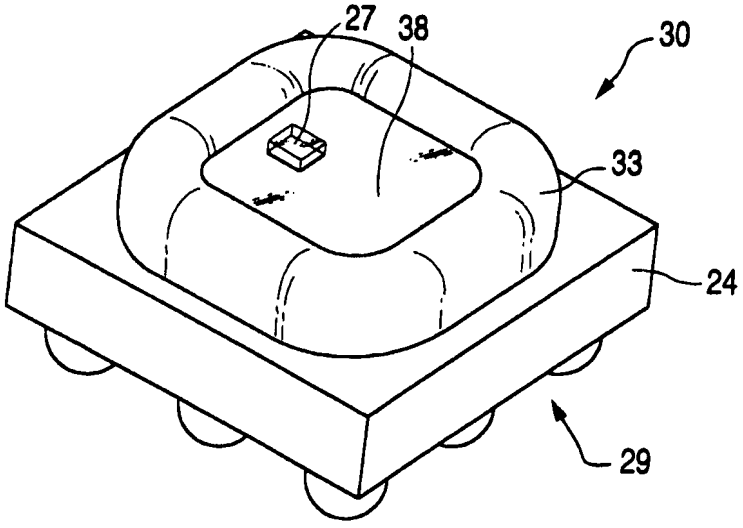

FIG. 6

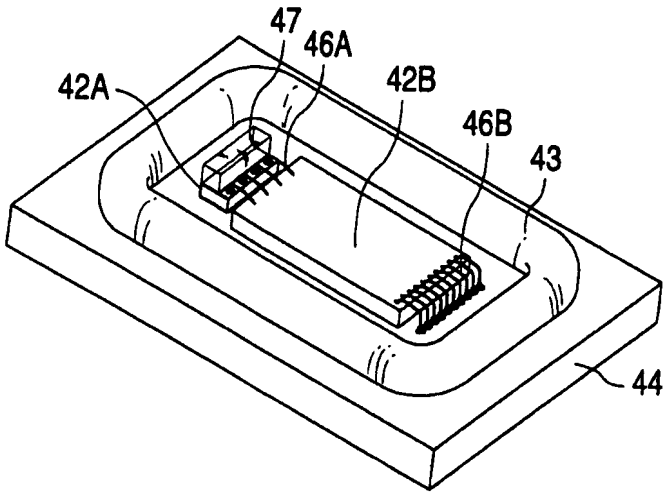

FIG. 7

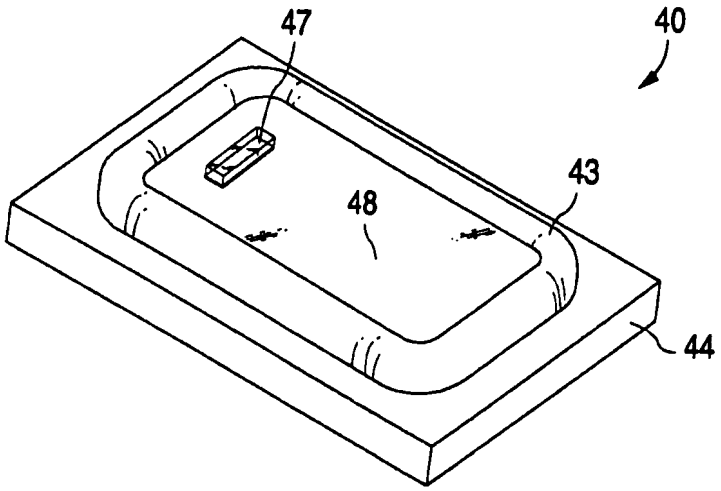

FIG. 8

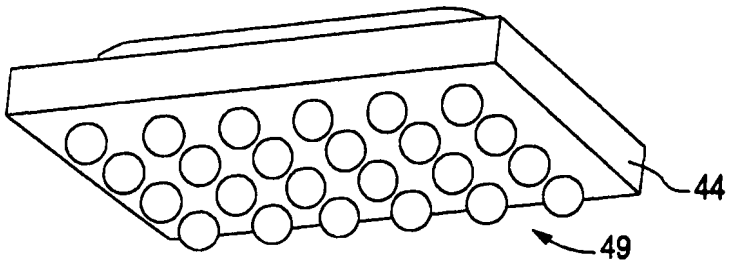

FIG. 9

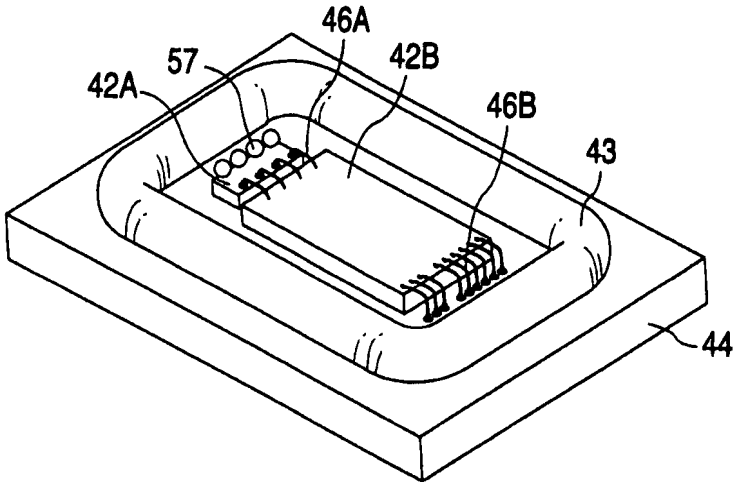

FIG. 10

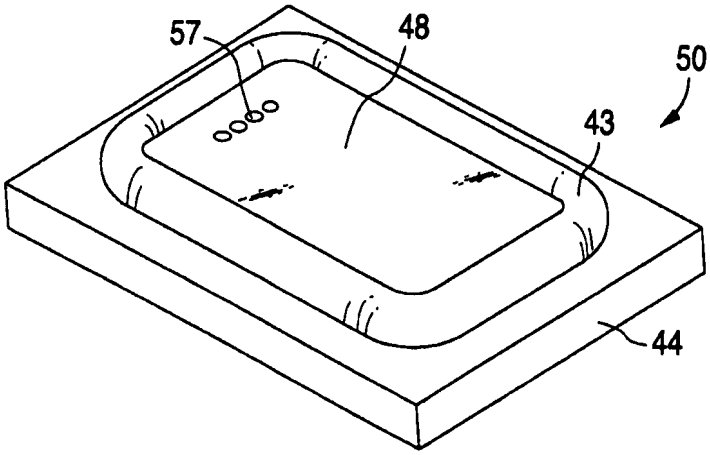

FIG. 11

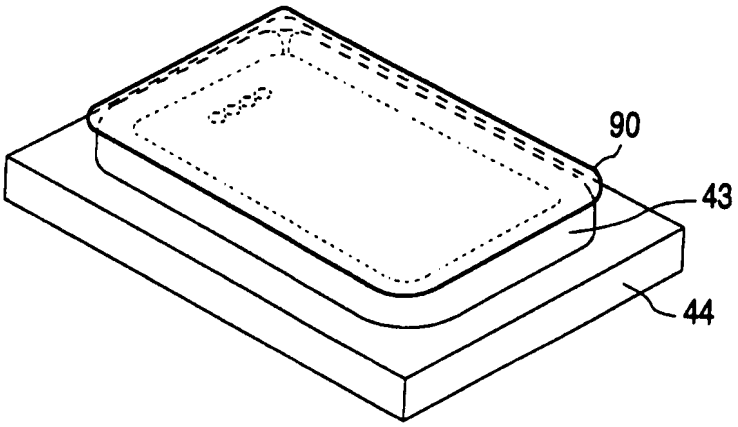

FIG. 12

OPTICAL SURFACE MOUNT TECHNOLOGY PACKAGE

[0001] A surface mount technology (SMT) package for optical devices finds application in fiber optics (FO). There are a wide variety of SMT packages available in the industry today for non-optical devices such as silicon integrated circuits (ICs). Options include leaded packages molded in epoxy, ceramic ball grid array (BGA), laminate BGAs and many others. These IC packages are available with thermally enhanced versions, multi-chip versions, low-cost versions, etc. No such abundance of optical SMT packages exists.

[0002] One of the least expensive ways to package an IC is chip-on-board (COB) as shown in Fig. 1. A die 12 is mounted directly onto a printed circuit board (PCB) 14 and wire bonds 16 make the connection between the traces on die 12 and traces on PCB 14. As shown in Fig. 2, environmental protection is provided by covering the device with an opaque epoxy 18 called "globtop." To reduce the coefficient of thermal expansion (CTE) of epoxy 18 so that thermal cycling does not overstress wire bonds 16, the globbing epoxy is heavily "filled" with a material that has a similar CTE as the PCB 14. Since filling materials (often silicon dioxide) are not transparent, COB 10 is generally not useful for optical devices. Thus, what is needed is a SMT package for optical devices.

[0003] In one embodiment of the invention, a semiconductor package includes a package substrate, an optical device die atop the package substrate, a transparent optical element atop the die, an optional dam around the die, and an encapsulant entirely covering the die and partially covering the transparent optical element.

[0004] Figs. 1 and 2 illustrate a conventional chip-on-board package.

[0005] Figs. 3 and 4 illustrate a package for an optical device in one embodiment of the invention.

[0006] Figs. 5 and 6 illustrate a package for an optical device in another embodiment of the

invention.

[0007] Figs. 7, 8, and 9 illustrate a package for an optical device in another embodiment of the invention.

[0008] Figs. 10 and 11 illustrate a package for an optical device in another embodiment of the invention.

[0009] Fig. 12 illustrates a method to protect one embodiment of the package during the assembly process in one embodiment of the invention.

[0010] Use of the same reference numbers in different figures indicates similar or identical elements.

[0011] Figs. 3 and 4 illustrate a surface mount technology (SMT) package 20 for optical devices in one embodiment of the invention. A die 22 is mounted on a package substrate 24. Die 22 includes an optical device such as a vertical cavity surface emitting laser (VCSEL), a light emitting diode (LED), or a photodiode. Package substrate 24 can be a printed circuit board (PCB) or a ceramic substrate. The bottom surface of package substrate 24 can be populated with a ball grid array (BGA) 29 to make the electrical connection to another substrate (e.g., a user's PCB). A trace on die 22 is connected by a wire bond 26 to a trace on package substrate 24.

[0012] A transparent optical element 27 is mounted on die 22 to create a window through a "globtop," which is formed by depositing an encapsulant 28 over package substrate 24. In one embodiment, window 27 is a rectangular piece of glass or quartz and encapsulant 28 is an epoxy filled with a material to provide similar coefficient of thermal expansion (CTE) as package substrate 24. The required transparency of window 27 is application specific (e.g., 10% to 100%). In one embodiment, window 27 is a lens that directs light, a filter that passes light of a certain wavelength, or a combination thereof. For environmental protection, encapsulant 28 is deposited on package substrate 24 to entirely cover die 22 and partially cover window 27. Window 27 is partially covered when its top surface is free of encapsulant 28 so that light can escape from or enter into die 22.

[0013] Figs. 5 and 6 illustrate a SMT package 30 for optical devices in one embodiment of

the invention. Similar to package 20, package 30 includes die 22, package substrate 24, wire bond 26, and window 27. Package 30 further includes a dam 33 formed around die 22, wire bond 26, and window 27 on package substrate 24. Dam 33 has a height greater than die 22 so it can be filled with an encapsulant 38 to entirely cover die 22 and partially cover window 27. This results in a substantially flat globtop with a slightly protruding window 27. In one embodiment, encapsulant 38 is similar to encapsulant 28. As shown, dam 33 has a generally rectangular shape with rounded corner but other shapes can be used to surround the components to be protected by encapsulant 38. In one embodiment, dam 33 is an epoxy that has the desired viscosity and flow properties to form the walls of the dam (e.g., a thixotropic epoxy).

[0014] Package 30 has several advantages. First, it is easy to control the amount of encapsulant 38 to dispense because the volume of material is confined within dam 33. Second, dam 33 produces a flat globtop that is easy to handle with vacuum pick-up heads used in conventional manufacturing processes.

[0015] Figs. 7, 8, and 9 illustrate a SMT package 40 for optical devices in one embodiment of the invention. Package 40 is similar to package 30. Instead of die 22, package 40 includes a die 42A that has multiple optical devices (e.g., four VCSELs). Furthermore, package 40 includes another die 42B that has the driver IC for the optical devices. Traces on dies 42A and 42B are connected by wire bonds 46A while traces on die 42B and package substrate 44 are connected by wire bonds 46B. For example, package 40 encompasses a four channel transmitter with the transmitter driver IC included in the package. As can be seen, a larger window 47 is mounted atop die 42A. A dam 43 surrounds die 42A, die 42B, wire bonds 46A, and wire bonds 46B. An encapsulant 48 fills dam 43 to entirely cover die 42A, die 42B, wire bonds 46A, and wire bonds 46B, and to partially cover window 47. The bottom of package substrate 44 can be populated with a BGA 49 to make the electrical connection to another substrate (e.g., a user's PCB).

[0016] Figs. 10 and 11 illustrate a SMT package 50 for optical devices in one embodiment of the invention. Package 50 is similar to package 40 except that window 47 has been replaced with lenses 57 (only one labeled for clarity) for each optical device. In one embodiment, lenses 57 are each a transparent spherical lens mounted atop die 42A over a corresponding optical device to direct light from or to the corresponding optical device.

[0017] Fig. 12 illustrates that if any of the packages described above (e.g., package 50) needs to be protected during the assembly process, the top of the package can be covered with a piece a tape 90.

[0018] Various other adaptations and combinations of features of the embodiments disclosed are within the scope of the invention. Numerous embodiments are encompassed by the following claims.

CLAIMS

1. A semiconductor package, comprising:

a package substrate;

a die atop the package substrate, the die comprising an optical device;

a transparent optical element atop the die; and

an encapsulant entirely covering the die and partially covering the transparent optical element.

2. The package of claim 1, wherein the transparent optical element is selected from the group consisting of a filter and a lens.

3. The package of claim 2, wherein the lens is selected from the group consisting of a rectangular lens and a spherical lens.

4. The package of claim 1, further comprising a dam surrounding the die, wherein the encapsulant is deposited within the dam.

5. The package of claim 4, wherein the dam comprises a thixotropic epoxy.

6. The package of claim 4, wherein the dam is rectangular with rounded corners.

7. The package of claim 4, wherein the optical device is selected from the group consisting of a laser, a light emitting diode, and a photodiode.

8. The package of claim 7, further comprising another die located inside the dam and covered by the encapsulant, said another die comprising a circuit driving the optical device.

9. The package of claim 1, wherein the package substrate is selected from the group consisting of a printed circuit board and a ceramic substrate.

10. The package of claim 1, wherein the package substrate comprises a ball grid array on a bottom surface.

11. The package of claim 1, wherein the die comprises an array of optical devices.

12. A method for creating a semiconductor package, comprising:

mounting a die atop a package substrate, the die comprising an optical device;

mounting a transparent optical element atop the die; and

depositing an encapsulant to entirely cover the die and to partially cover the transparent optical element.

13. The method of claim 12, wherein the transparent optical element is selected from the group consisting of a filter and a lens.

14. The method of claim 13, wherein the lens is selected from the group consisting of a rectangular lens and a spherical lens.

15. The method of claim 12, further comprising, prior to said depositing an encapsulant, forming a dam around the die, wherein the encapsulant is deposited within the dam.

16. The method of claim 15, wherein the dam comprises a thixotropic epoxy.

17. The method of claim 15, wherein said forming a dam comprises forming a rectangular dam with rounded corners.

18. The method of claim 15, wherein the optical device is selected from the group consisting of a laser, a light emitting diode, and a photodiode.

19. The method of claim 18, further comprising, prior to said depositing an encapsulant, mounting another die on the package substrate, said another die comprising a circuit driving the optical device, wherein the dam surround the die and said another die and the encapsulant covers the die and said another die.

20. The method of claim 12, wherein the package substrate is selected from the group consisting of a printed circuit board and a ceramic substrate.

21. The method of claim 12, wherein the package substrate comprises a ball grid array on a bottom surface.

22. The method of claim 12, wherein the die comprises an array of optical devices.

23. A semiconductor package substantially as herein described with reference to each of Figs. 3 to 12 of the accompanying drawings.

24. A method for creating a semiconductor package substantially as herein described with reference to each of Figs. 3 to 12 of the accompanying drawings.

Application No: GB0509064.2 **Examiner:** Mr Steven Morgan

Claims searched: 1 & 12 **Date of search:** 16 August 2005

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1, 4, 5, 7-12, 15, 16 & 18-22	US2003/0075355 A1 (ANDERSON) See para's 49-138
X	1, 4, 5, 9, 12, 15, 16 & 20	US6049094 A (NATIONAL SEMICONDUCTOR) See for example figure 5
X	1, 2, 12 & 13	US5863810 A (EURATEC) See for example figures 3d & 6
X	1, 2, 12 & 13	DE19536216 C1 (SIEMENS) See abstract & figure

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Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application

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H01L; H01S

The following online and other databases have been used in the preparation of this search report

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